

## **Astronomy as a “Neutral Zone”: Interreligious Cooperation in Medieval Spain**

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### **Abstract**

Interreligious cooperation on philosophical and scientific matters was part of the legacy of the culture developed under Muslim auspices in Baghdad in the ninth and tenth centuries. This kind of cooperation continued in both Muslim and Christian Spain, although there are instances where Jews and Christians did not wish to call attention to it. Several episodes from the twelfth to the fifteenth centuries involving astronomers are examined in detail to illustrate both “open” and “discreet” cooperation among Jews and Christians in medieval Spain. Alfonso X of Castile (d. 1284) is well known as a patron of both Jewish and Christian astronomers, and the compilation of the *Alfonsine Tables* of Toledo was a notable achievement. The case of Abraham Zacut (d. 1515) of Salamanca is also discussed, and some myths about him are dispelled.

### **Keywords**

Abraham Ibn Ezra, *Alfonsine Tables*, Abraham Zacut, Azarchiel, John Vimond

Astronomy was one of the most intensively studied scientific disciplines in the Islamic world, beginning in the eighth century in Baghdad. There were two main traditions, Indian and Greek, that were fundamental for subsequent research in this domain. The first tradition to reach Baghdad came from India, but it was largely displaced by the Greek tradition that arrived a few years later. In both cases there were translations into Arabic, and shortly thereafter adaptations by Muslim astronomers. It is customary now to refer to a Renaissance in Baghdad in the ninth century, for the level of astronomical research far exceeded that which took place in the immediately preceding centuries (Goldstein, “Making of Astronomy in Early Islam”). In general, high culture flowed from Baghdad to the provinces, and this included the study of astronomy. Thus, both Greek and Indian

traditions were transmitted to al-Andalus, which were the basis for further work by Muslim, Jewish and Christian astronomers in Spain and, later, in other parts of Europe as these ideas were diffused from Spain (Samsó). The Greek tradition, mainly based on the *Almagest* of Ptolemy (who lived in Alexandria, c. 150), was represented in Spain by the Arabic treatise of al-Battānī (who lived in Raqqa on the upper Euphrates, c. 900) and the Indian tradition by the Arabic treatise of al-Khwārizmī (who lived in Baghdad, c. 840). The treatise of al-Battānī survives as a complete text in only one Arabic manuscript (now in the Escorial Library), and it was translated, in some cases with modifications, into Hebrew, Latin and Castilian (Nalino). The Arabic text of al-Khwārizmī is not extant; a version of it in Arabic was composed by Maslama al-Majrīṭī (c. 1000) in al-Andalus, and it too is lost. However, a Latin translation of al-Majrīṭī's version ascribed to Adelard of Bath (fl. 1130) survives (Suter; Neugebauer). Moreover, a commentary in Arabic on al-Khwārizmī's tables, composed in al-Andalus by Ibn al-Muthannā (tenth century), survives in two Hebrew versions (one of which is by Abraham Ibn Ezra, d. 1167) and in a Latin version by Hugo Sanctallensis (fl. 1150; Goldstein, *Ibn al-Muthannā's Commentary*; Millás Vendrell).

There was a great deal of activity in translating Arabic texts into Hebrew and Latin in the twelfth century owing, in part, to the prestige of Arabic culture in general, and astronomy in particular, that was keenly felt by the Jewish and Christian communities in both Muslim and Christian Spain. Throughout the medieval period Jews and Christians in the Iberian Peninsula, both separately and together, continued to make contributions to the study of astronomy. As we will see, astronomy was a "neutral zone" in which scholars of one faith had no problem borrowing ideas from scholars of another faith. A few episodes will also illustrate various ways in which Jews and Christians cooperated, sometimes openly while at other times "discreetly." As historical background, one should be aware that the Christian conquest of Toledo from the Muslims in 1085 led to the entry into al-Andalus of fanatical groups from North Africa, namely, the Almoravids in 1090 and the Almohads in 1149 (Lapidus 314), who were, in general, hostile to the Jewish community (Gampel 20-21). By the middle of the twelfth century, most Spanish Jews lived in Christian Spain. Nevertheless, Jews retained their knowledge of the Arabic language and culture.

To set the stage, let me begin with a quotation from Abraham Ibn Ezra's introduction to his Hebrew translation of Ibn al-Muthannā's commentary on the astronomical tables of al-Khwārizmī. This report on the early devel-

opment of astronomy in the Islamic world is, however, a historical romance, loosely based on the facts.

In ancient days, neither wisdom nor religion was found among the Arabs who dwell in tents, until the author of the *Qur'ān* arose and gave them a new religion from his heart.<sup>1</sup> After [Muḥammad] wise men came who composed many books on their religious law, until there arose a great king of the Arabs whose name was al-Safāḥ [the first caliph of the 'Abbāsid dynasty who reigned from 750 to 754]. He heard that in India there were many sciences and so he ordered that a wise man be sought, fluent in both Arabic and the language of India, who might translate one of the books of their wisdom for him. He thought that some mishap might befall the translator because profane sciences were still unknown in Islam. They had only the *Qur'ān* and wise traditions which they received from Muḥammad... [Al-Safāḥ] fasted... in the hope that the angel of dreams might appear and permit the book to be translated for him into Arabic. Then in a dream he saw what he had hoped for. So he sent for a Jew who knew both languages and ordered him to translate this book, for he feared that if an Arab were to translate the book, he might die. When he saw how wonderful the book was,... he yearned for more knowledge of the sciences of India... He gave great wealth to the Jew... so that he might travel to the city of Arin [in India]... thinking "perhaps he will succeed in bringing one of their wise men to the king." So the Jew went and indulged in many subterfuges after which, for a large sum, [Kanka,] one of the wise men of Arin, agreed to go to the king... Then from this scholar, with the Jew as an Arabic-Indian interpreter, a scholar named Jacob ben Sharah [i.e., Ya'qūb ibn Ṭāriq] translated a book containing the tables of the seven planets, ... the arrangement of the astrological houses, knowledge of the fixed stars, and eclipses of the luminaries. (Goldstein, *Ibn al-Muthannā* 147-148)

Now for the facts: there was a delegation from India to Baghdad that included scholars who brought Indian astronomy to the Muslims in the late eighth century, that is, the transmission of ideas was facilitated by the actual presence of scholars coming from a different culture. Ya'qūb ibn Ṭāriq in the late eighth century produced a set of astronomical tables based on Indian traditions. Although it is now extant only in fragments (Pingree), it served as the basis for the astronomical tables of al-Khwārizmī which were influential in Spain. *Arin* is a corrupt form of Ujjain, a city in India. No Jew was involved in this translation: Ibn Ezra simply assumed it to be the case since, in Spain, Jews often served as intermediaries in translations from Arabic into Latin. As Marie-Thérèse d'Alverny reports,

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<sup>1</sup> Clearly this statement is a polemic against the Muslim claim that the *Qur'ān* was revealed to Muḥammad by the angel, Gabriel. However, Ibn Ezra rarely makes such polemical remarks in his scientific works.

in twelfth-century Spain (and later), Jews assisted in the translations from Arabic into Latin according to the following procedure: a learned Jew would read the Arabic text and translate it orally word-for-word into the vernacular, e.g., Castilian, in the presence of a Christian cleric who then translated what he heard into Latin and wrote it down. This method is sometimes called a four-handed translation. Despite the difficulties with the details of Ibn Ezra's account, I would argue that he understood the "spirit" of this age of translation under the patronage of the early 'Abbāsids. As A. I. Sabra has stressed, this translation movement was part of an "appropriation" of Greek (and to a lesser extent Indian) culture, that is, an integration of it into Islamic culture. Moreover, he has argued that this activity in early Islam was not a marginal phenomenon; rather, it was a major cultural enterprise undertaken under the protection and patronage of the caliphs and, in its intensity and scope, had no precedent either in the Middle East or elsewhere. Dimitri Gutas adds that support for this movement "cut across all lines of religious, sectarian, ethnic, tribal and linguistic demarcation. Patrons were Arabs and non-Arabs, Muslims and non-Muslims, Sunnis and Shi'ites, generals and civilians, merchants and land-owners, etc." (Gutas 5).

Perhaps the most important astronomer in al-Andalus was Azarquiel (d. 1100), a prolific writer on astronomical subjects, many of whose works were translated into Hebrew and Latin. He was associated with Šā'id al-Andalusī (d. 1070) who wrote a history of scientific contributions up to his time, with a focus on Muslim Spain (Richter-Bernburg). Azarquiel composed an astronomical almanac in Arabic which was later translated into Castilian. One of his important works, *On the Motion of the Fixed Stars*, only survives in a Hebrew version. Moreover, the *Toledan Tables*, ascribed in the Middle Ages to Azarquiel, are not extant in Arabic, but the Latin versions of the twelfth century were dominant in Christian Europe north of the Pyrenees in the thirteenth century. The *Toledan Tables* were partially displaced by the Parisian *Alfonsine Tables* in the mid fourteenth century, although many extant copies of the *Toledan Tables* date from the fifteenth century. The evidence for the names of the Latin translators is weak, according to Fritz S. Pedersen who produced a monumental edition of the *Toledan Tables* with commentary (Pedersen 15). The tables themselves depend primarily on al-Battānī, but some parts derive from al-Khwārizmī. They are arranged for the Muslim calendar, which was not very convenient for the users who surely preferred the Christian calendar. Indeed, the earliest Latin version, the *Tables of Marseilles*, dated c. 1140,

were arranged for the Christian calendar, as were several other versions compiled before the end of the thirteenth century. However, judging from the number of extant copies, none of them was as popular as the versions based on the Muslim calendar.

Ibn al-Kammād (fl. 1115) was a Muslim astronomer who lived in Córdoba. He composed three sets of astronomical tables, none of which survives in the original Arabic. A Latin version of one set was translated by John of Dumpno in 1260 in Palermo, Sicily (Chabás and Goldstein, "Andalusian Astronomy"). More recently, a Hebrew version by Solomon Franco (perhaps from Córdoba; fl. 1370) has been identified in which the author explicitly says that "I depended for most matters on *al-Zij al-Muqtabis*," that is, on the astronomical tables of Ibn al-Kammād (Vatican, ms Heb. 498, fol. 2r; Langermann, "Two Astronomical Treatises"). Both the Latin and the Hebrew versions are arranged for the Muslim calendar, and the author of these tables was widely cited by his Muslim, Christian and Jewish successors in Spain. Of particular note is the impact of these tables on the Tables of Barcelona, originally composed in Hebrew for the king, Don Pedro el Ceremonioso of Aragón (1319-1387), and then translated into Latin and Catalan (Chabás, "Astronomía"). Don Pedro was also a patron of the Jewish astronomer, Jacob ben David Bonjorn, called in Hebrew by the nickname *ha-po'el*, or 'the [table]maker,' whose main work in astronomy was also composed in Hebrew and then translated into Catalan and Latin (Chabás, "The Astronomical Tables").

The Latin and Hebrew versions of the tables of Ibn al-Kammād contain tables for the mean motions of the Sun, the Moon and the five planets in years, months and days, in the Muslim calendar. There are also tables for the "equations" (as they were called in the Middle Ages), for finding the true positions of the planets from their mean positions which, in turn, require a calculation of the apogee of the given planet, that is the position on the ecliptic where the planet is farthest from the Earth. In the Middle Ages it was assumed that there were seven planets all of which revolve around the Earth: Moon, Sun, Mercury, Venus, Mars, Jupiter and Saturn.

For Ptolemy, the sun's apogee was fixed with respect to the vernal equinox, the point where the ecliptic (the Sun's apparent yearly path through the zodiac) crosses the celestial equator. In the ninth century Muslim astronomers in Baghdad argued that the solar apogee is fixed with respect to the fixed stars rather than with respect to the vernal equinox. Then in the eleventh century Azarquiel found that the solar apogee also has a proper motion of  $1^\circ$  in about 279 Julian years, and Ibn al-Kammād modified

Azarquiel's parameter slightly to  $1^\circ$  in about 290 Julian years (Chabás and Goldstein, "Andalusian Astronomy" 28). This motion of the solar apogee was accepted by many, but not all, astronomers in Spain (and by those who depended on their works), but not by astronomers elsewhere in the Islamic world. In some cases, followers of Ibn al-Kammād agreed with his view that this motion applied to the apogees of the five planets, that is, the apogees of each of the five planets was at a fixed distance from the (moving) solar apogee. This motion is not included in the *Toledan Tables* or the *Alfonsine Tables* (about which more later), the most widely diffused sets of astronomical tables in the Latin West. However a Parisian astronomer of the early fourteenth century, John Vimond, included this motion of the solar apogee and applied it to the planetary apogees as well. In other words, several different Iberian astronomical traditions reached Paris in the early fourteenth century; in particular, some of them were not included in the Parisian version of the *Alfonsine Tables*.

Abraham Bar Ḥiyya of Barcelona (d. c. 1145) was the first Spanish Jew to write scientific treatises in Hebrew; usually he composed paraphrases rather than translations. In particular, he adapted the tables of al-Battānī to the Hebrew calendar (Millás Vallicrosa, *La obra Séfer Ḥeshbon*; Goldstein, "Astronomy in the Medieval Spanish Jewish Community"). The works of Bar Ḥiyya were quite popular, and this meant that knowledge of the Ptolemaic tradition in astronomy was widely available in the Jewish community. Plato of Tivoli, who resided in Barcelona, translated the Arabic version of an astrological work by Ptolemy into Latin with the help of Bar Ḥiyya (Millás Vallicrosa, *Traducciones* 153) and then in 1145 translated a mathematical work composed in Hebrew by Bar Ḥiyya into Latin, probably with the assistance of the author, entitled *Liber embadorum* (Lévy espec. 40, 53-54).<sup>2</sup> Bar Ḥiyya created a scientific vocabulary in Hebrew, based on Arabic models, that was certainly appreciated by his successors. A similar endeavor was undertaken by Abraham Ibn Ezra who preferred to add new meanings to biblical terms (Goldstein, "Astronomy and Astrology"). Ibn Ezra also composed commentaries on various books of the Hebrew Bible, and he used these commentaries to spread scientific ideas to the broad community. It has recently been argued that some scientific works ascribed to Ibn Ezra were written by him in Latin, possibly with the help of a Christian assistant, rather than translated from Hebrew by some-

<sup>2</sup> For another astrological work translated from Arabic into Latin by Plato of Tivoli in collaboration with Bar Ḥiyya, see Millás Vallicrosa, *Traducciones* 328-339.

one else (Sela 22-36; Smithuis). If true, this would be another early instance of cooperation in scientific matters between a Jew and a Christian. Ibn Ezra also wrote extensively in Hebrew on astrology, based on traditions drawn from Arabic texts. These Hebrew treatises, considered an encyclopedia of astrological lore, were later translated into Latin by Henry Bate of Mechelen/Malines in 1281 (Goldine 15; Sela and Freudenthal).

So far I have focused on the intellectual debts of Jews and Christians to their Muslim predecessors in al-Andalus. Next I turn to the well-known collaboration of Jews and Christians under the patronage of Alfonso X of Castile (d. 1284), whose goal was to provide Castilian scholars engaged in studying the sciences with a working library, mainly in the Castilian language. Some texts were translated from Arabic into Castilian, others into Latin via a Castilian intermediary (Chabás and Goldstein, *Alfonsine Tables* 225-241). We can glean an idea of the kind of collaboration that was undertaken from the following episode. In *The Book of the Fixed Stars*, we are told that the king was involved in the revision of this treatise, first translated by Judah ben Moses Cohen with the help of Guillén Arremón Daspa in 1256. This Castilian translation was later revised in 1276 by the same Judah, another Jewish scholar (Samuel ha-Levi) and two Italians, with the active participation of the king (Chabás and Goldstein, *Alfonsine Tables* 234-235).

In the prologue to the Castilian translation of another treatise, *The Lapidary*, we learn of Alfonso's personal involvement with—and dependence on—learned Jews in 1243, even before he became king:

[Alfonso] obtained [the Arabic manuscript] in Toledo from a Jew who kept it hidden, who neither wished to make use of it himself nor that any other should profit therefrom. And when he had this book in his possession, [the king] caused another Jew, who was his physician, to read it and he was called Jehuda Mosca el menor. [This Jew] was learned in the art of astrology, and knew and understood well both Arabic and Latin. And when through this Jew his physician, [the king] understood the value and great profit which was in the book, he commanded him to translate it from Arabic into the Castilian language, so that men might better understand it and learn how to profit from it. And one Garci Pérez his clerk aided in this translation. He too was learned in the art of astrology. (Procter 19)

In the course of these translations, a scientific vocabulary had to be invented in Castilian, and this was not a simple task.

In addition to translations, there was one particularly important original text composed at the court of Alfonso, *The Alfonsine Tables of Toledo*, of

which only the Castilian canons (instructions) are extant. The authors were two Jews, and no Christians are mentioned in the prologue other than the king who served as patron.

Judah, son of Moses, son of Mosca, and Rabbi Isaac ibn Sid say: The science of astrology is a subject that cannot be investigated without observations. Yet, the observations made by the experts in this discipline cannot be completed by a single man; indeed, they cannot be completed in the lifetime of one man. On the contrary, when a result is attained, it is attained through the work of many men, laboring one after another for a long time. The reason for this is that among the celestial motions are some that are so slow that they only complete a circuit after thousands of years. It is therefore necessary to continue making observations because, by proceeding in this way, phenomena will become apparent at one time that were not apparent at another time. We are now in our time in the first decade of the fourth century of the second millennium of the era of Caesar [1262-1272]. Two hundred years have passed since Azarquiel's observations, and discrepancies have appeared in some of the positions, which he adopted, that are so obvious and manifest to the senses that no excuse can be offered for [retaining] them. At this time there appeared the happy reign, assisted by God, the rule of the very exalted and most noble lord, King Don Alfonso, may God preserve him! Because he loved learning and appreciated it, he had instruments made, such as the armillary sphere and other devices, that are described by Ptolemy in the *Almagest*. And he bade us observe in the city of Toledo, one of the principal cities in Spain—may God preserve it!—in which Azarquiel made his observations. [Don Alfonso] ordered [us] to rectify and correct the divergences and disagreements that had appeared in some positions of some of the planets and in other motions. We obeyed his order as he demanded of us, reconstructing the instruments as best we could. We worked at making observations for a certain length of time and proceeded to observe the Sun throughout a complete year... We also observed many eclipses of the Sun and Moon. We made [some] other observations in which we had doubts but repeated them many times to resolve the doubt; we did not abandon searching and investigating anything until the way to correct that which was in need of correction became evident to us... We call this book, the book of the *Alfonsine Tables*, because it was made and compiled at the behest [of Don Alfonso], and we have divided it into 54 chapters, which follow. (Chabás and Goldstein, *Alfonsine Tables* 136-137)

Isaac ibn Sid, also called Rabi Çag of Toledo, was the most prolific scientific collaborator of Alfonso X. Judah ben Moses ha-Cohen was a physician who, during the reign of Fernando III, Alfonso's father, had completed a translation into Latin of Azarquiel's *Treatise on the Azafea* in 1231. Under the patronage of Alfonso, he took part in the translation of several treatises from Arabic into Castilian. The prologue stresses the importance of observations, which in fact had little impact on the tables. In a Hebrew treatise, Isaac Israeli of Toledo (c. 1310) reports four solar and lunar eclipses by



Alfonso's collaborators, and this is the sum total of the evidence for astronomical observational activity at the court of Alfonso (Chabás and Goldstein, *Alfonsine Tables* 141-143). In particular, no specific dated observations are mentioned in the fifty-four chapters that follow this prologue. Azarquiel's observations were made in 1075, which is approximately 200 years before this text was composed. The king ordered his astronomers to correct previous astronomical tables, but it is not entirely clear which set of tables he had in mind.

In 1504, while in Tunis, Abraham Zacut wrote a lengthy history, *The Book of Genealogies*, in which he praised the tables of Alfonso:

In the year 5012 A.M. [=1252], on the last day of May, Don Alfonso began to reign. He was a lover of the sciences, in particular of astronomy. At that time the scholar, Rabbi Isaac ben Sid, ḥazzan of Toledo, prepared tables for the host of the heavens with great precision at the command of the king, and no previous tables or books on astronomy had their precision... And from the east to the west, in Germany, France, England, Italy, and Spain, astronomers have destroyed all their former tables and used these tables in their stead until this very day. (Chabás and Goldstein, *Alfonsine Tables* 236)

Zacut was well informed since it is true that, at the time he was writing, astronomers in the countries he listed overwhelmingly depended on, and developed, Alfonsine astronomy. Poland is the only country in Christian Europe in which significant astronomical activity took place that he omits. One aspect of this activity was to find clever ways to make the tables more "user-friendly," reducing the number and complexity of calculations required for determining astronomical data for a specific date. The ingenuity involved is truly amazing, but in no way challenged any of the fundamental assumptions underlying the tables.

The canons in Castilian were published in 1866 and since then it has been a puzzle to see their relationship with the *Alfonsine Tables* in Latin that were diffused from Paris, beginning in the 1320s. It is noteworthy that in the Latin version the Jewish collaborators are not mentioned at all; the tables are simply ascribed to King Alfonso. There is only one hint in Latin of Jewish participation in this project, and it occurs in a text by John of Lignères, a Parisian astronomer in the 1320s who was one of the principal collaborators in the Parisian version of the *Alfonsine Tables*. He wrote: "Abraham Benthegar composed canons that have not yet been translated from Hebrew, although it seems to me from what I have heard that they are the best of all, with the exception of those of al-Battānī" (Chabás and

Goldstein, *Alfonsine Tables* 282). The reference is unclear since no one by this name is known, but it can be assumed that John of Lignères had the *Alfonsine Tables* in mind. There are many problems in taking this Abraham to be the same as Abraham Ben Waqār, one of Alfonso's translators, for he is not the author of any works in Hebrew and there are linguistic difficulties with the identification. John is, however, certainly indicating his admiration for tables that came to Paris from somewhere else.

My colleague, José Chabás, and I have carefully considered the impact of Alfonsine treatises on the astronomers in Paris in the early fourteenth century. One connection is a description of planetary velocity tables in the Castilian canons, which is almost identical with the Latin description of such tables in a treatise by John of Lignères, composed some fifty years later. The close correspondence of these texts is an indication of data coming from Spain to Paris in the 1320s or shortly before (Goldstein, Chabás and Mancha). Another set of evidence comes from the tables of John Vimond who was not part of the group that compiled the Parisian *Alfonsine Tables*, although he was in Paris at the same time. Vimond's tables have many features in common with the Parisian *Alfonsine Tables*, but they are mainly hidden from view by a completely different presentation. They also have features that distinguish them from the Parisian *Alfonsine Tables*, while still reflecting Spanish traditions (Chabás and Goldstein, "Early Alfonsine Astronomy"). It has already been mentioned that Vimond, like some of his Spanish predecessors, held that the solar apogee has a proper motion, and that the planetary apogees maintain a fixed distance from this moving solar apogee, a feature completely missing in the Parisian version of the *Alfonsine Tables*. Vimond, however, says nothing about his sources in the brief text that accompanies his tables.

A key for understanding the early development of the Parisian *Alfonsine Tables* is found in the *Expositio* by John of Murs, another major Parisian astronomer active in the 1320s. In this text John of Murs explains the parameters and models that underlie tables he has in hand; he refers to the tables of Alfonso ("Alfonsius... in capite tabule motus solis") and to the introduction to these tables ("ut invenit Alfonsius causa introductionis tabularum eius" [Chabás and Goldstein, *Alfonsine Tables* 279-280]). The Parisian *Alfonsine Tables* survive in hundreds of copies; they were the most popular set of astronomical tables in Europe until late in the sixteenth century. Unfortunately, there is no general survey of these manuscripts, but it has been shown that there are significant differences among their various families (Chabás, "From Toledo to Venice"; North). José Chabás

and I refer to the many versions of the *Alfonsine Tables* and related texts as the “Alfonsine corpus,” all of which are part of the legacy of astronomy as it was practiced at the court of Alfonso.

Unlike Europe north of the Pyrenees where the Parisian *Alfonsine Tables* predominated in the fifteenth century, a variety of astronomical traditions flourished in the Iberian Peninsula at that time. In particular, Judah Ben Verga of Lisbon (c. 1470) cites predecessors who wrote in Arabic and Hebrew, but not in Latin or the vernacular. His original astronomical tables are unrelated to the Parisian *Alfonsine Tables* and survive in two Hebrew manuscripts, recently identified by Y. Tzvi Langermann of Bar Ilan University in Tel Aviv. Given the obligation of Muslims to pray towards Mecca five times a day, finding the direction to Mecca from any location is a common topic in Arabic astronomy; the direction to Jerusalem, however, was rarely treated in medieval Hebrew sources. Ben Verga is an exception: in his *Treatise on the Horizontal Instrument*, he states the problem as that of finding the direction to Jerusalem from any city, and then gives Lisbon as his example. By way of contrast, Ben Verga says nothing about astronomical navigation, despite the contemporary activities of Portuguese explorers (Langermann, “Science in the Jewish Communities”; Goldstein, “The Astronomical Tables” and “Preliminary Remarks”).

Finally, let us consider the case of Abraham Zacut (1452-1515), who was active in Salamanca and other places in Castile before the Edict of Expulsion of the Jews in 1492. Afterwards he spent time in Portugal, North Africa and then in Jerusalem. Let us first dispense with the myth of Zacut’s role in the Portuguese voyages of discovery. The key support for this claim comes from Gaspar Correia, who mentions Zacut’s name a few times in his historical account of the age of discoveries, written long after the time when Zacut was in Portugal. Correia’s date of birth is not known, but he died c. 1561. He wrote an eight-volume work, *Lendas da Índia*, published in Lisbon (1858-1866). In this book he claims that before sponsoring the voyage that led to the discovery of India, King Manuel consulted Zacut on weather and storms occurring during long-distance navigation, and that Zacut gave instructions to pilots concerning the use of astronomical instruments at sea. Without entering into a discussion of Correia’s general reliability, his account of Zacut giving instructions to navigators at sea seems dubious. Zacut had lived in Salamanca and later in Extremadura—far from the sea. I know of no evidence suggesting that Zacut had even been near the sea or on board a ship prior to his arrival in Portugal. Moreover, he did not discuss astronomical instruments in any of

his known works, and did not mention the application of astronomy to problems of navigation (Chabás and Goldstein, *Astronomy in the Iberian Peninsula* 9-11). So, while the possibility exists that there was some interaction between Zacut and navigators and explorers, better information is needed from a source that is closer in time to Zacut's sojourn in Portugal than what is provided by Correia. Luís Albuquerque, a leading Portuguese historian of astronomical navigation, considered Correia's account of Zacut teaching the use of nautical instruments to Portuguese pilots as suspect: "Correia can be forgiven for this error, because he wrote his text in India, and in the passage he refers to a subject with which he was not familiar, and of which he could not be well informed, because he did not have access to archives or to anyone who could inform him better" (Albuquerque 144, translated in Chabás and Goldstein, *Abraham Zacut* 9, n. 8).

In astronomy Zacut is best known for the *Almanach Perpetuum*, published in Leiria, Portugal, in 1496, with versions in Latin and Castilian. Although this text is based on Zacut's Hebrew treatise, *ha-Hibbur ha-gadol* (*The Great Composition*), the canons in Latin and Castilian are entirely different from those in Hebrew, and there are other differences in the tables themselves. Zacut's canons in Hebrew are clearly addressed to a Jewish audience and he refers to many Jewish astronomers who preceded him. The canons in the Latin and Castilian versions are not translations from Hebrew, and only one Jewish astronomer is mentioned in them. A dedication to an unnamed bishop of Salamanca in the Latin version of the *Almanach Perpetuum* has been the basis for much speculation. But the fact of the matter is that this dedication was taken almost verbatim from a dedication by Johannes Regiomontanus to a Hungarian archbishop in a work that was published posthumously in Augsburg in 1490. The main change was to replace Regiomontanus' Vienna by Salamanca. No such dedication is found in the Hebrew version, and there is no reason to believe that Zacut had anything to do with it. Indeed, in his later works Zacut never referred to the Latin version of his *Hibbur*. The text of this dedication has been the sole support for the claim that Zacut was either a student or a teacher at the University of Salamanca, a claim that must now be abandoned (Chabás and Goldstein, *Abraham Zacut* 90-95).

For the purposes of this essay, it is important to note that Zacut does not acknowledge any of his contemporaries in Salamanca although there is considerable indirect evidence for interactions between them. Zacut depended on the Parisian version of the *Alfonsine Tables* which had been absent in Spain, despite their widespread diffusion north of the Pyrenees,

until the tables arrived in Salamanca with Nicolaus Polonius, the first incumbent of the chair of astronomy at the University of Salamanca, who came from Poland c. 1460 (Chabás and Goldstein, *Abraham Zacut* 20-21; see also Chabás, "Astronomy in Salamanca").

The clearest evidence of interaction comes from a Castilian translation of the canons to Zacut's *Hibbur*, completed by Juan de Salaya in 1481, three years after Zacut had composed them in Hebrew. In the colophon, Juan de Salaya, who held the chair of astronomy at the University of Salamanca from 1464 to 1469, tells us that Zacut helped him in translating the Hebrew text (Cantera Burgos 236). I see no alternative to the assumption that the assistance came in the form of face-to-face conversations. Recently, in examining a set of astronomical tables in Hebrew that Zacut composed in Jerusalem in 1513, I found evidence of the tables of Nicolaus de Heybech of Erfurt who lived c. 1400 (New York, Jewish Theological Seminary of America, ms 2574, fols. 8b-9b; Chabás and Goldstein, "Nicholaus de Heybech"; Goldstein and Chabás, "Transmission of Computational Methods"). These tables, compiled in Latin, have many distinctive characteristics, and no Hebrew version of them is known. Although there is no trace of them in his *Hibbur*, Zacut used them (without indicating his source) long after he had left Spain. The solution to this puzzle, as suggested to me by José Chabás, seems to be that Heybech's tables were available in Salamanca, and they were incorporated in an anonymous Latin text, the *Tabule verificate* for Salamanca, whose epoch is 1461 (Chabás and Goldstein, *Abraham Zacut* 28).

Zacut's astronomical works were regularly consulted by his Christian neighbors in Salamanca, but their indebtedness to him was rarely acknowledged. For example, Diego de Torres, who held the chair of astronomy at the University of Salamanca in the 1480s, depended on Zacut's tables for his computations, but does not mention Zacut in his work (Chabás and Goldstein, *Abraham Zacut* 165-166). Another puzzle concerns Zacut's relation with Gonzalo de Vivero, bishop of Salamanca (d. 1480). The only evidence (if we disregard conjectures by modern scholars) comes from the testament of the bishop in which he ordered that "the Jew Abraham, astrologer" be given a modest amount of money, and that there be bound in a single volume to be put in his library "the notebooks which are in Romance (i.e., Castilian) and written by this Jew . . . in order to understand better the tables by this Jew" (Chabás and Goldstein, *Abraham Zacut* 7-8, 95; Cantera Burgos 76). It is reasonable to assume that this Jew is Abraham Zacut (there is no alternative candidate), but the relationship between him

and the bishop is otherwise unknown. It is hard to avoid the conclusion that in the years leading up to the Expulsion, it was not considered prudent for Christian or Jewish scholars to discuss their intellectual interactions openly.

Although it has long been known that the study of astronomy in Spain by Muslims, Jews and Christians had a great impact on astronomers north of the Pyrenees, the interactions of scholars from these various religious communities in Spain has been relatively neglected. Astronomy was a neutral meeting ground for scholars who were sharply divided on religious questions. The practice of scholarly meetings by participants with different religious commitments began in Baghdad in the ninth and tenth centuries and, as al-Kindī (d. c. 870) argued: "For the seeker of truth nothing takes precedence over the truth, and there is no disparagement of the truth, nor belittling either of him who speaks it or of him who conveys it" (Gutas 158-159). However, later in the Middle Ages such encounters rarely took place except in the Iberian Peninsula, where it can be seen as a significant cultural phenomenon over a long period of time.

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